Recreational Scuba Diving in the Strait of Georgia: An Analysis of the Distribution of Diving Effort and the Importance of Collecting Marine Animals

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November 1984

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1794

85-3398/

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Fisheries and Aquatic Sciences No. 1794

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RECREATIONAL SCUBA DIVING IN THE STRAIT OF GEORGIA: AN ANALYSIS OF THE DISTRIBUTION OF DIVING EFFORT AND THE IMPORTANCE OF COLLECTING MARINE ANIMALS

by

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Cat. No. Fs97-4/1794E ISSN 0706-6473

Correct citation for this publication:

McElderry, H. I. and L. J. Richards. 1984. Recreational SCUBA diving in the Strait of Georgia: An analysis of the distribution of diving effort and the importance of collecting marine animals. Can. MS Rep. Fish. Aquat. Sci. 1794: 61 p.

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ABSTRACT

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The characteristics of recreational SCUBA diving in the Strait of Georgia were examined using a two-part survey design. Twenty-three dive shops bordering the study area logged airfills for a one-month period commencing 15 October 1983. A self-administered questionnaire survey was conducted concurrently at ten of these locations to determine the personal characteristics and diving habits of participating divers. A total of 4700 recreational dives were estimated for the study period divided among sample regions as follows: Vancouver (62%), Victoria (22%), Nanaimo (7.4%), Campbell River (4.9%) and Powell River (3.6%).

Based on airfill estimates and dive descriptions of 155 respondents, the intensity of diving effort was highest near major urban centers. Outer Howe Sound had the highest reported level followed by West Vancouver, Saanich Inlet, Porlier Pass, Nanoose-Northwest Bay, upper Howe Sound, southwestern Gulf Islands, Skookumchuck-Agamemnon Channel, the Victoria waterfront and the Sechelt area.

The survey was used to assess the importance of fish and shellfish collection by divers. Over 60% of the respondents collected some type of fish and over 70% collected some type of edible invertebrate in 1983. On their most recent dive, 40% collected fish and 44% collected invertebrates. These results suggest that food collection by divers is a very common and regular event although few dives seem to occur for this purpose alone. Based on the average catch rate and the estimated number of collecting dives, the numbers collected per thousand sport dives were estimated as 693 for lingcod, 487 for rockfish, 1172 for abalone, 488 for Dungeness crab and 903 for rock scallop. Because of the short study period and small sample size, survey results should be carefully interpreted.

Key words: SCUBA, spearfishing, sportfishing, Strait of Georgia

RÉSUMÉ

McElderry, H. I. and L. J. Richards. 1984. Recreational SCUBA diving in the Strait of Georgia: An analysis of the distribution of diving effort and the importance of collecting marine animals. Can. MS Rep. Fish. Aquat. Sci. 1794: 61 p.

Les caractéristiques de la plongée autonome sportive dans le détroit de Géorgie ont fait l'objet d'une étude à deux volets. Vingt-trois magasins de matériel de plongée situés dans la zone étudiée ont enregistré les remplissages de réservoir pendant un mois à partir du 15 octobre 1983. En même temps, une enquête par questionnaires à remplir soi-même a été menée à dix de ces magasins afin de déterminer les caractéristiques personnelles et les habitudes de plongée des plongeurs participants. On a évalué à 4700 le nombre de plongées sportives pendant la période étudiée, ventilées de la façon suivante entre les régions observées: Vancouver (62%), Victoria (22%), Nanaïmo (7.4%), Campbell River (4.9%) et Powell River (3.6%).

Selon les estimations des remplissages et les descriptions des plongées faites par 155 répondants, l'intensité de l'effort de plongée a été la plus élevée près des principaux centres urbains. En ordre décroissant, les régions utilisées étaient: partie extérieure de la baie Howe, Vancouver-Ouest, inlet Saanich, passage Porlier, Nanoose-baie Northwest, partie supérieure de la baie Howe, partie sud-ouest des îles Gulf, chenal Skookumchuck-Agamemnon, plages de Victoria et région de Sechelt.

On a utilisé l'enquête pour évaluer l'importance de la prise de poissons, de mollusques et de crustacés par les plongeurs. Plus de 60% d'entre eux ont pris des poissons et au-delà de 70% ont ramassé des invertébrés comestibles en 1983. Au cours de leur dernière plongée, 40% et 44% des répondants ont respectivement capturé des poissons et des invertébrés. Ces résultats indiquent que la cueillette d'aliments par des plongeurs est une activité régulière et très commune quoique peu de plongées semblent effectuées à cette seule fin. Selon le taux moyen de capture et le nombre estimatif de plongées de cueillette, on a effectué les estimations suivantes du nombre d'animaux capturés par 1000 plongées sportives: 693 morues-lingues, 487 sébastes, 1172 ormeaux, 488 crabes dormeurs et 903 hinnites géants. A cause de la période d'étude limitée et de la faible taille de l'échantillon, les résultats de l'étude doivent être soigneusemenet interprétés.

Mot-clés: plongée autonome, pêche au harpon, pêche sportive, détroit de Géorgie

INTRODUCTION

SCUBA diving is a form of underwater recreation enjoyed by a wide variety of people. The sport originated in the 1940s, when the compressed air breathing apparatus became available to the general public in an inexpensive and reliable form. Since then a rapid growth has occurred and it is estimated that there are over 2.1 million participants in North America (Ernst et al. 1980). In British Columbia, the sport has probably grown more slowly because of the secondary requirement of good thermal protection for the cold temperate waters. Despite this, diving has become very popular as the local waters offer spectacular diving opportunities that rate among the best in North America.

Among a variety of underwater activities, divers participate in the collection of marine animals and can thus be considered as a separate, albeit small fishery. In British Columbia, the characteristics of this fishery have not been examined although the Strait of Georgia Creel Survey (DPA 1982) and the Tidal Diary Program (Bijsterveld 1983 and unpublished data) include SCUBA as one category of fishing. Reliance on these information sources assumes that participants in the diving fishery are as susceptible to interview as are participants in other forms of the recreational fishery. However, the creel survey collects samples from launch ramps and marinas where divers using shore access may not occur, and the Tidal Diary Program subsamples from the population of licensed saltwater anglers which includes spearfishing but not shellfish collecting. Consequently, an independent form of sampling is necessary to study the British Columbia SCUBA fishery.

Two research programs have established a precedent for a sampling program to assess recreational SCUBA fisheries. In California, creel surveys were conducted in 1960 and 1972 for the specific purpose of interviewing divers (Miller et al. 1974). This program encompassed 700 miles of coastline and involved 2996 and 15,030 interviews for the two years respectively. The 1972 survey estimated a total of 95,194 diving days (1 diving day = 1.34 hours) of which training was first (37.5%) followed by observing (27.5%), spearfishing (22.9%) and photography (5.6%). During the 1960 survey, spearfishing was the most frequent activity (62.9%) followed by observing (18.6%), training (10.0%) and abalone diving (3.5%) with a diving effort of 37,872 days. The sport underwent a 2.5-fold increase and a dramatic change in activity patterns during this 12-year period. Unfortunately, this information has not been updated.

A more recent program was initiated by the Washington State Department of Fisheries (G. G. Bargmann 1984). A creel survey of divers was conducted at dive sites, similar to the California study. The interviews enumerated diver club and non-club members separately and this ratio, together with an estimate of the total dive club population, provided an estimate of the total diver population.

Here we characterize the recreational SCUBA fishery in British Columbia using a two-stage survey. For the first stage, airfill records were collected from participating dive shops. The second stage was a questionnaire

given to customers at a subset of these dive shops. Unlike the studies described above, the program was limited to a short time period (one month) and small geographic area (Strait of Georgia).

MATERIALS AND METHODS

STUDY AREA

The study area was the inside waters of southern B.C. extending from the southern extent of Johnstone Strait (Kelsey Bay) throughout the Strait of Georgia and into the northeastern portion of Juan de Fuca Strait (Fig. 2). This region, hereafter referred to as 'the Strait of Georgia' is approximately 10,000 square km in overall area. Over 70% of the population of B.C. live on bordering land. With the high tourism influx, this region has the highest overall level of recreational use in the province.

STUDY DESIGN

The study was conducted using interview and public survey as the basic tool of data collection. Initially, contact was made with dive shop managers and other participants in the Strait of Georgia diving industry in order to discuss the general study objectives and to determine the most suitable sample opportunities. As a result of this initial contact, a survey format was designed that consisted of two distinct parts to be implemented concurrently. The objective of the first part was to estimate airfills for the Strait of Georgia area based on all known dive shops and air stations. The second part of the survey consisted of a self-administered questionnaire distributed to a subsample of the dive shops. The survey was conducted during the month prior to the seasonal closure for lingcod (15 October to 15 November 1983), a period when spearfishing activities may be more prevalent.

Airfill Records

In order to estimate the level of sport diving, dive shops in the Strait of Georgia area (Table 1) were requested to maintain a log of airfills during the survey period. The sum of estimates from all air stations provided an approximate measure of diving effort, although airfills obtained from privately owned compressors were not included. These were few in number and tended to be associated with remote parts of the study region.

A blank calendar was used as a logsheet and posted near the tank filling station. Shop personnel were requested to record all private recreational airfills, defined as airfills or tank rentals that were to be used by private individuals for recreational purposes. Not included were

airfills or tank rentals used for purposes such as diving instruction, commercial or research use, or commercially organized diving trips (charter boat and/or group outings).

Questionnaire Survey

The questionnaire survey was intended to provide a general description of the diving population, and more importantly, the characteristics of the airfills measured by the logsheets. The questionnaire consisted of one page (front and back) and took about 5 minutes to complete (Fig. 1). In conjunction with the questionnaire was a large scale (50 x 56 cm) map of the study area (Fig. 2) divided into 74 areas. Divers were requested to describe their personal diving habits and their recent dives by date, area and activity.

Questionnaire sample locations were selected primarily on the basis of geography, and secondarily on subjective impressions of store suitability. Initially, ten locations were chosen in the five geographic regions (Table 1). An additional location was later included to supplement sampling in the Nanaimo area.

Prior to distribution the questionnaire was pre-tested with 25 individuals. In this procedure, major emphasis was placed on questionnaire clarity and comprehension by the test group.

Airfill logsheets and questionnaire material were distributed to the sample locations before the beginning of the survey period. The map was prominently displayed near a convenient counter or writing surface. Each sample location received a package of 100 questionnaires and a sheet of instructions explaining the sampling procedures. Regular contact was made with the sample locations to monitor progress. At the end of the survey period, a personal visit was made to all locations to collect the material and to discuss the study with store personnel.

RESULTS

ESTIMATION OF DIVING EFFORT

Logsheets were distributed to 23 locations in the study area. Most dive shops made a sincere effort to keep accurate records. All but four locations provided daily records for all or part of the survey period and of these, two were able to provide an overall estimate based on their sales records. Airfills from the other two locations were estimated using locations of apparently comparable activity.

The results from the airfill logsheets are summarized in Table 2. Also given are the total number of days these locations were open for business and the proportion of this time that the logsheets were maintained. In cases where incomplete records (i.e., missing days) occurred, the totals were estimated by extrapolation. There were eight such locations with missing day proportions ranging from 0.31 to 0.93; the overall average for 19 locations combined was 0.87 (i.e. participating shops logged 87% of total survey days). It is evident that locations with lower airfill estimates provided more complete logsheets than did those locations with high airfills. The latter were generally busier and had less time to maintain these records. A common comment at these shops was that they kept up the logsheet for a while but became too busy and stopped recording airfills.

One potential source of error was missing entries. Usually this would occur when a storekeeper would forget or simply become too busy to stop and fill out the logsheet. In discussing this problem with store managers, it was generally felt that the logsheet entries closely represented the level of airfill activity and that entries periodically missed were often possible to complete during less active periods.

The airfill values presented in Table 2 indicate that diving activity in the Strait of Georgia during the one-month survey period consisted of over 4700 airfills. The general distribution of these airfills was approximately proportional to the overall population. Vancouver accounted for slightly more than 60% of the airfills, Victoria for 22% and the remaining three regions combined represented 15%.

Other sources of compressed air were not censused but were identified during the course of the study. These included four locations on the Sunshine Coast, two locations on Galiano Island (Gulf Islands) and one location on Hornby Island. While few of these locations were contacted, it was assumed that the number of airfills contributed by these sources was small in comparison to that provided by the 23 sample locations.

CHARACTERISTICS OF DIVING ACTIVITY

General Response Characteristics

All but one of the participating dive shops provided completed questionnaires from their customers, although the number of responses was lower than expected and unevenly distributed over time (Fig. 3). While the distribution of airfills (calculated using complete logsheet records only) remained essentially constant over time, the number of questionnaire responses declined rapidly after the first week. There are two possible explanations. First, the survey design relied upon the store personnel to select respondents and encourage their participation. This task was initially carried out with interest but declined over time. Second, many of the divers surveyed were active in the sport and probably returned to the shop several times during the survey period (see Level of Experience).

In Table 3, responses are shown by sample location and geographic area. During the survey period 146 questionnaires were completed and returned. Because of low representation in the Nanaimo area, supplementary sampling from another dive shop was conducted during a one-day period in mid-December. This sampling increased the returns to a total of 155 from the entire study area. The numbers of responses and airfills from individual shops were not related as a result of the high variability in participation by the shops. The relative distributions of questionnaires and airfills by region were similar although Vancouver was under-represented (47% vs 62%) and Powell River was over-represented (11% vs 3.5%).

A potential source of error in this type of survey results from bias in selecting the survey participants. This sample problem was carefully explained to shop personnel and described in a handout prior to the survey. At the completion of the survey the issue was again discussed. Store managers felt that the people sampled were representative of their normal clientele and when requested, customers were usually willing to participate.

Residence

Respondents were scored as resident if they lived in the same town as the participating dive shop or a nearby town without diving services. On this basis, 90% of the respondents were residents of the sample locations. The 16 visitors were from locations outside the Strait of Georgia including southern interior B.C. (13), Alberta (2) and U.S.A. (1). In Table 4, residents and visitors are separated by sample location. The major urban areas (Victoria and Vancouver) had a significantly lower prorortion of visitors than the other three locations (Chi-square, $p \tilde{} 0.05$).

Level of Experience

The second questionnaire topic defined the respondent's level of experience in terms of the total number of recreational dives they had completed. Four response categories were provided which are roughly equivalent to experience levels of beginner (less than 50 dives), intermediate (50 to 100 dives), advanced (100 to 500 dives), and expert (greater than 500 dives). The sample population consisted primarily of advanced divers (36.1%) followed by beginner (29.7%), intermediate (20.0%) and expert (14.2%) experience levels, although all levels were well-represented (Table 5).

The Number of Dives per Year by Season

This was an open format question, requesting the number of dives carried out in each of the past three seasons (winter, spring, summer) and the expected number of dives for the present season (fall). The question presented difficulty for respondents as 30% left one or more categories blank. The 109 usable responses were sorted on the basis of experience level (Fig. 4). Annual diving activity increased with experience although the pattern was quite variable, particularly among the higher experience levels.

Seasonal patterns in diving activity were also examined by experience level. Using Friedman's test (Zar 1974) a significant ($p<0.05$) seasonal rank order in diving intensity occurred among the beginner category and not among the other three experience groups. Most respondents in the beginner category had probably learned to dive recently as recorded dives were usually entered for the most recent seasons only. Overall, there were no consistent seasonal patterns in diving activity among the survey participants.

Dive Characteristics

General Description of the Data: Respondents were requested to describe their recent dives by time (month), area (numerical map region) and principal activity (one of five categories). Space was provided for six dive descriptions; five of these were designated as recent dives (past) and the sixth as the next dive (future). A total of 715 dive descriptions were obtained from 155 questionnaires, approximately 80% of the maximum number possible. The distribution of descriptions by sample location and geographic region is shown in Table 6. The number of dive descriptions per respondent was similar for each geographic region with an overall rate of 4.6 dive descriptions per respondent. Seventy-one respondents (46%) omitted the next dive category. They had probably not planned an upcoming dive.

The distribution of dive descriptions by month is shown in Figure 5. Of 715 dive descriptions, 671 (94%) were properly dated and usable for this analysis. Descriptions were given for all months of the year although the majority (84%) were for the August to November period. The 23 December dives were from the late sample collected in Nanaimo.

As dive descriptions from October and November represent a sample of the airfills provided by the dive shop, the ratio of dive descriptions and airfills provides a rough estimate of the sample rate. These rates range from 5% in Vancouver to 27% in Powell River (Table 7). However, the time periods for the airfill and dive descriptions were not measured to the same degree of resolution. The former were measured daily from mid-October to mid-November while the latter were by month. As a result, the dive descriptions potentially include a 1.5 month period, assuming an equal distribution of responses over the survey period. Hence, the sample rate could be at least 33% lower than calculated as the distribution was not even over time. A second reason for an inaccurate estimate of sample rate is that dives are almost always carried out by two or more people. Assuming that each questionnaire was independent (i.e. the respondent's dive partner did not fill out a questionnaire) the sample rate could double. These cases are presented in Table 7 as the minimum and maximum range.

Geographic Distribution of Dive Effort: The dive descriptions provide a means of describing the overall distribution of diving effort within the Strait of Georgia. First it is necessary to select a representative time period and calculate area scaling factors based upon the number of dives within this period. Dives that occurred in the September through November period were selected for use as these were expected to be typical of the fall period and also represented a reasonable proportion of the sample (73%). Inclusion of the September dives was necessary to increase the sample size.

Table 8 gives the ratio of airfills to dive descriptions by geographic region. These values describe the area scaling factor or degree of resolution for each region. For example, one dive description in Vancouver represented 13.94 dives while one dive description in Powell River represented 2.67 dives for the one month survey period. When plotted together, the Vancouver scaling factor defined the minimum resolution common to all areas.

Dive descriptions were sorted on an area basis as identified in Figure 2. Of 76 possible areas, 56 were represented by at least one dive and 41 by two or more dives. Areas represented by more than one dive were often described by more than one person (Fig. 6).

The 488 dive descriptions from the fall period were distributed as follows: the Strait of Georgia (86%), west coast Vancouver Island (3%), U.S. locations (2%), Interior areas (1%) and unspecified (8%). Figure 7 shows the geographic distribution of the Strait of Georgia areas with values scaled according to the geographic airfill estimate. The most popular area was lower Howe Sound with an estimated 714 dives. Other areas of high diving activity were West Vancouver (421), Saanich Inlet (339), Porlier Pass (240), Nanoose-Northwest Bay (220), upper Howe Sound (167), southwestern Gulf Islands (167), Skookumchuck-Agamemnon Channel (154), the Victoria waterfront (130) and Sechelt (103). Among the remaining areas, 6 had 51 to 100 dives estimated, 17 had 15 to 50 dives and 21 had less than 15 total dives which was the minimum resolution used. Seventeen areas had no recorded diving activity. Of these, five were remotely located at the heads of major inlets; three were less remote but not easily accessible (west shore Texada Island, east shore of Valdez Island and Mitlenatch Island); two were primarily beach areas with little attraction (Qualicum Beach, southeast Saanich Peninsula); and three of the remaining five areas were in the Comox-Courtenay area where no dive descriptions were obtained. The remaining two were Pender Harbour and Gibsons which was unexpected. If dive descriptions for all months are combined, four of the last five areas are described (northeast shore of Comox remains excluded).

The maps presented in Figures 8 through 12 describe diving activity by geographic region. These maps indicate the important diving areas with a level of resolution appropriate for each region.

From Vancouver, where over 60% of the diving effort originated, dives were made throughout the Strait of Georgia (Fig. 8). Sixty-four percent of the diving effort occurred in areas adjacent to Vancouver with the majority in Howe Sound (36.6%) and West Vancouver (17.4%). Outside Vancouver, the principal areas were southern Vancouver Island (17.4%) and the Sechelt Peninsula (11.7%).

Diving areas from the Victoria region are shown in Figure 9. This region accounted for approximately 22% of the total diving effort. All of the diving areas were within southern Vancouver Island. Diving effort was primarily concentrated in Saanich Inlet (34.8%), the southwestern Gulf Islands (27.7%) and the Victoria waterfront (12.5%).

The Nanaimo region (Fig. 10) represented 7.5% of the total Strait of Georgia diving effort. Dive areas of highest activity were Northwest-Nanoose Bay (46.2%) and Departure Bay-Gabriola Island (23.1%).

The Campbell River region (Fig. 11), represented 2.5% of the total diving effort. The highest level of diving activity was in Discovery Channel (65.8%). Dive locations to the east of Quadra Island and Kelsey Bay were also important.

Diving activity based in the Powell River region (Fig. 12) had a broader geographic distribution than for other sample regions. This region represented 3.6% of the total Strait of Georgia diving effort. Important dive areas were Powell River and Westview (22.7%), Lund (20.2%), Desolation Sound-Okeover (18.8%) and northern Texada Island (11.3%).

Several diving areas were common to two or more sampling regions. To determine the extent of area overlap, visitors were excluded from the data set and dive descriptions were compared for both the September through November period and for all months combined. Diving effort from two or more sample regions occurred at 14 areas for the fall period and 34 areas for the year. Most of the overlap areas were the result of interactions between the two regions (e.g., Nanaimo and Victoria) although three-region overlap occurred at five locations during the year.

Distribution of Diving Effort by Activity: The dive description section of the questionnaire also detailed the types of activities in which divers participate. Respondents were requested to indicate the principal activity intended during each dive from the following choices: sightseeing, photography, spearfishing, collection of edible items and collection of non-edible items. While any dive may consist of a variety of activities, the selection of one item was intended to identify the most important activity. The total dive description sample of 715 dives (from Table 6) provided 585 dives (82%) with usable activity designations. Those dives not usable (130) were either filled out by multiple entries (65%) or were left blank.

The relative importance of the various activities was evaluated by two methods. In both cases, the data were selected from dives during the September through November time period. The first method defined the relative importance of activities as the number of divers that participated in that activity by sample region (Fig. 14). In general, sightseeing was the most common activity and was listed by over 50% of the respondents from each sample region. The remaining activities were considerably less popular and the order of importance was not consistent among sample regions. This was probably due to limited sample size and regional differences in the availability of opportunities. Overall, spearfishing and collection of edible items ranked second in importance at four of the sample regions with values ranging from 20% to 38% (Fig. 14). Collection of non-edible items and photography had generally low ranks.

The distribution in Figure 14 was calculated using area weighting and assumed that the distribution of airfills was proportional to the distribution of divers (i.e. diver participation was constant for all areas).

By this procedure, 10% of the divers participated in photography, spearfishing and collection of edible items, about 5% participated in the collection of non-edible items and the remaining 63% participated in sightseeing dives.

The second method used to evaluate the importance of the five activities was the number of dive descriptions indicated for each activity. This method accounted for the fact that divers repeat certain activities more than others. For example, dives primarily for sightseeing and photography averaged 2.8 and 2.7 per diver. In contrast, divers who spearfished or collected edible items also participated in other activities such as sightseeing. Ratios of 1.8 and 1.5 dives per diver were calculated for spearfishing and collection of edible items, respectively. Collection of non-edible items had a ratio of 2.1 dives per diver. In comparison with the first method, the relative importance of sightseeing and photography increased and spearfishing and collection of edible items decreased (Fig. 15) although differences were small.

One question to test with these data is whether more advanced divers select the same types of activities as beginners. The distribution of dives (all areas and seasons combined) by diver experience level and activity type is shown in Table 9. While the dives were not independent observations and could not be easily compared statistically, it is apparent that the distribution of activities changed with experience level. Sightseeing declined and photography increased with experience level. The occurrence of spearfishing dives was very low among beginner divers and similar among other experience levels. There were no apparent patterns between experience level and dive activities that involved the collection of edible and non-edible items.

For an individual diver, increased experience may influence either the types or diversity of diver activities (or both). To examine the relationship between experience level and activity diversity, respondents were separated by experience group and scored according to the number of different activities listed in their dive descriptions (Table 10). There were no consistent patterns among experience levels although the percentage of divers who participated in more than one activity ranged between 28% and 52%.

Activity Participation

Respondents were requested to indicate the percentage of dives that were associated with each of the five activities on a six-point scale (see Fig. 1). Figure 16 shows the frequencies of dives that were attributed to each activity for the total sample population. Sightseeing involved most of the sample group (94%), and many spent most of their time with this activity. Approximately 50% of the respondents indicated they made dives in 1983 for the purpose of spearfishing and collection of edible items. However, few respondents indicated that these activities involved more than 20% of their dives. Collection of non-edible items (36%) and photography (29%) generally accounted for less than 20% of the total dives conducted.

Collection Habits

The last portion of the survey concerned the general habits for collecting marine life. A list of commonly collected fish and invertebrates was provided and respondents were requested to rank each animal on a scale of one (collected when available) to three (not taken). Additionally, respondents were requested to indicate the number of these animals taken on the last dive. Table 11 presents the general collection habits for each marine animal by all respondents combined. Shown are the percentages for each of the three collection categories and the mean rank value for all respondents. The fish and invertebrates are listed in decreasing order of mean preference.

This type of analysis identifies the relative collection preferences for different marine animals. Among the fish groups examined, lingcod were the most preferred followed by rockfish and 'other fish'. Abalone, Dungeness crab and rock scallops had nearly identical scores ranking as the most preferred invertebrates and second in collection preference to lingcod. Few respondents collected the remaining six invertebrates listed. Octopus had the lowest rank.

A second method to evaluate collection preferences for these animals is presented in Table 12. Shown are the percentages of respondents who indicated collection: (a) on occasion or when available and (b) during their last dive. Among fish, lingcod collection was the most common: 60% of the respondents collected lingcod at some time and 35% of the divers collected lingcod on their last dive. In contrast, 35% of the divers collected rockfish and 18% collected rockfish on their last dive. Among the invertebrates, approximately half of those surveyed collected abalone, Dungeness crabs and rock scallops at some time. The percentage of divers who collected these animals on their last dive ranged from 17% to 22%. Rock crab had collection values of 31% and 12% for the overall and last dive categories, respectively. The remaining invertebrate categories were collected by fewer than 25% of the respondents and fewer than 10% collected these animals on their last dive.

The bottom rows in Table 12 summarize the categories by general animal type. Collection values for "any fish" were similar to those of lingcod as most divers collect lingcod when they spearfish. Overall, 74% of the divers collected 'any shellfish'. The largest percentage of divers who collected any single invertebrate was 50% for abalone. Hence, either collection preferences for invertebrates differ among divers or opportunities differ as a result of geographic patterns of animal distribution. Overall, 78% of the respondents collected something edible and 53% collected something edible on their last dive.

Collection rates are shown in Figure 17 for divers that collected animals on their last dive. These values do not include divers that had planned to collect but were not successful. For lingcod, abalone, rock scallops, Dungeness crabs and rock crabs the maximum number collected was influenced by the bag limit. Collection in excess of the limits was reported for all groups although the incidence was generally less than 10% except for

Dungeness crabs (20%, 5 of 25 respondents). The most common catch was one or a few animals for lingcod, rockfish, abalone and rock scallops. The most common number collected for Dungeness crabs and rock crabs was the bag limit of four. Collection patterns were probably due to both availability and the quantity necessary to make collection worthwhile.

A simplified calculation was made to estimate the total harvest of marine animals by divers during the survey period. The total catch for each animal was estimated as the product of the mean catch and the total number of collecting dives. The former value was the mean number of animals collected on the last dive and the latter value was derived as follows:

$$N_i = \sum_{a=1}^{5} F_a \, P_{ia}$$

N_i is the total number of collection dives for animal i
F_a is the total airfill estimate for sample area a
P_{ia} is the proportion of divers that collected animal i on their last dive in area a.

Table 13 shows the combined effect of collection rate and collection effort on the estimated number of animals collected. The total catch is presented as the estimated number during the one month survey period, and as the number per 1000 sport dives. While these values were not expected to be very accurate, comparisons among animals are useful. The high estimate for swimming scallops was the result of the high catch rate in spite of the 8% collection effort (Table 12). Abalone was ranked second in total number collected; over 1100 collected per one thousand sport dives were estimated. Other high catches were rock scallops (903), prawns (835), lingcod (693), Dungeness crab (588) and rockfish (487).

GENERAL DISCUSSION

SURVEY DESIGN

The survey technique used in the present study provided a simple means of asessing diving activity, as SCUBA divers generally obtain their airfills from a commercial source. Other potential interview locations were dive sites or principal access points such as launch ramps and marinas. There are numerous popular dive sites in the Strait of Georgia (Pratt-Johnson 1977; Anon. 1984) and a field-oriented survey of diving activity would be a large sampling task. As much of the diving activity was shore based, information obtained from the creel survey, where samples are collected from launch ramps, would probably be of little value. Consequently, dive shops were the most practical sample source.

On the basis of information provided by this study, a two-part sample design could be used to effectively monitor the activities of a SCUBA 'fishery'. The use of logsheets to measure diving effort was a simple and inexpensive sampling method. Most dive shops were interested in the study and made a sincere effort to keep careful records. The reliability of this form of sampling was difficult to assess, however. Airfill records were not regularly kept by dive shops and there was no verification of the accuracy of log sheet entries. The ability to keep accurate log sheets was limited by available time and proper judgement (deciding which airfill to record), both of which were inversely proportional to the level of store activity. Compressor logs and sales records are limited in value as secondary estimates of airfills. Compressor use does not easily translate into recreational airfills as the number of other uses are unknown and probably varies from store to store. While airfills are usually listed separately in sales records, interpreting the number of recreational airfills is not reliable because of separate prices for different sized tanks and quantity air sales such as an air card which is good for 10 tank fills. Dive shops often offer tank fills at reduced rates during sales, or free with the purchase of major equipment (e.g. free air for a year with the purchase of a SCUBA tank), or as a measure of good will when a customer feels dissatisfied. Future sampling using this method should include an estimate of the error caused by inaccurate reporting of airfills.

Airfills obtained from sources not contacted in the study were probably insignificant as few divers have their own compressor. Private air sources are the primary means to diving access in remote coastal areas, however. Consequently, the geographic distribution of diving effort using airfill logsheets may underestimate the level in these areas.

There are no reliable estimates of the size of the overall diving population. Ernst et al. (1980) stated that there are approximately 40,500 certified divers residing in B.C. and an additional 4,600 non-residents who dive annually in B.C. It is not known what proportion of this total are active in the sport and how their diving efforts are distributed over the year. Without this information it is difficult to assess the representativeness of the samples from the various dive shops.

The questionnaire portion of the survey included questions on personal diving characteristics and details of individual dives. The 'next dive' category was probably confusing to respondents who were not anticipating an upcoming dive. It would have been more useful to refer to the most recent dive instead, as this was also identified in the collection habits section. The requirement for reference to a single dive activity was not as useful as a complete list as many dives involved more than one activity. These improvements would provide a more direct means of estimating harvest than was performed in the present study (Table 13).

One sampling problem arose from the collection of multiple dive descriptions from a single respondent. Dive descriptions from the same respondent were not statistically independent. While multiple dive descriptions should be included in relation to a diver's activity, the geographic distribution of diving effort will be biased when there are few independent observations. For example, there were 20 dive locations that were described by one respondent only (Fig. 6).

RECREATIONAL DIVING IN THE STRAIT OF GEORGIA

Interpretation of the survey results was limited by the small sample size and the short time period over which information was collected. The airfill logs indicated a monthly activity of over 4,700 airfills. Two separate sources, based on monthly dive shop sales records (confidential source) and the Tidal Diary Program (Bijsterveld unpublished data) indicate that the survey period represented 6.5% and 2.9% respectively of the total annual activity. Using these values the annual Strait of Georgia recreational SCUBA diving effort was estimated as between 76,000 and 172,000 dives. These values are considerably lower than the estimate by Ernst et al. (1980) of 300,000 annual dives in British Columbia, most of which take place in the Strait of Georgia.

While summer is the season of highest diving activity, winter is considered to be the best time of the year to dive in B.C. During this period planktonic organisms are less abundant so that there is a dramatic increase in water clarity. The more favourable diving conditions in winter seem to attract the more experienced divers. In this survey, 70% of the respondents had logged more than 50 dives (Table 5) and 88% dive at least 10 times per year (Table 6). The national average in the United States is 15 dives per year (Professional Association of Diving Instructors unpublished data). Consequently, the effort described during the one-month survey was below average and the diver population had an above average level of experience and participation.

The geographic areas in the survey were designed to provide an acceptable resolution for the Strait of Georgia as a whole. Individual areas had different numbers of dive sites. Boat access, for example, was necessary in some areas. Consequently, diving effort may differ if areas of apparently similar diving effort had a different number of available dive sites. The important areas identified in the survey generally represent good dive sites that are readily accessible. The importance of these sites is probably independent of season. From Vancouver, the major diving effort occurred in outer Howe Sound with upper Howe Sound and West Vancouver as other important areas. From Victoria, Saanich Inlet was the most popular area followed by the southwestern Gulf Islands and Victoria waterfront. Important diving areas near Nanaimo were Nanoose-Northwest Bay and Gabriola Island-Departure Bay. The major diving area near Campbell River was Discovery Passage. Diving based in Powell River was more widespread with areas from Lund to Saltery Bay of equal rank.

A final aspect of the survey concerned spearfishing and shellfish collection habits of SCUBA divers. The levels of spearfishing and collection-edible recorded as principal activities in the dive descriptions were less than 10% overall (Fig. 14,15). Approximately 50% of the divers interviewed indicated that at least some of their dives in 1983 were devoted to one of these activities (Fig. 16). On the basis of collection preferences, 61% of the divers indicated they collected some type of fish and 74% some type

of shellfish (Table 12). During the survey 53% of the sample group collected something edible on their last dive, 40% collected fish and 44% collected shellfish (Table 12). Consequently, food collection by divers is a very common and regular event although few dives seem to occur for this purpose alone.

The collection patterns reported here may not be typical of the entire year. Divers active during the survey period were more experienced than average and consequently, this group may have better water skills and more 'hunting' experience. The water clarity during the survey period was generally better than during the summer, so that it was easier to identify particular habitats where desired animals may occur. In addition, the survey covered the one month period prior to the seasonal closure of lingcod. At this time lingcod come to nest and spawn in shallow water areas so that they are easier to collect. Because of the harvesting closures, more lingcod are probably collected as divers take advantage of the last collection opportunity. Further studies are needed to discern these seasonal patterns.

ACKNOWLEDGMENTS

This study could not have been possible without the enthusiastic support of the 23 participating dive shops. Peggy Frank and Elisabeth Hooke produced the artwork and drafting, respectively. The study was funded under DFO contract 03SB.FP597-3-8084 to Archipelago Marine Research.

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Table 1. Distribution of dive shops and sample regions surrounding the Strait of Georgia.

Location	Number of dive shops	Questionnaire sample locations
Vancouver	13	4
Victoria	4	2
Nanaimo	2	2[a]
Campbell River[b]	2	2
Powell River	2	1
Total	23	11

[a]Initially one sample.
[b]Includes Comox and Courtenay.

Table 2. Estimates of recreational airfills obtained from Strait of Georgia air stations. "est." indicates airfill number estimated. "sales" indicates number was determined from sales records.

Location	Number of days open	Proportion sampled	Number of airfills	Percent
Vancouver				
1	24	0.88	197	
2	26	1.00	169	
3	26	0.31	814	
4	26	1.00	69	
5	26	1.00	125	
6	26	est.	468	
7	28	0.93	104	
8	26	0.65	234	
9	26	0.81	246	
10	22	0.59	112	
11	31	0.48	112	
12	26	1.00	126	
13	11	1.00	152	
			2928	61.7
Victoria				
1	32	0.91	633	
2	26	1.00	223	
3	32	1.00	50	
4	31	1.00	153	
			1059	22.3
Nanaimo				
1	26	sales	18	
2	26	sales	334	
			352	7.4
Campbell River				
1	25	1.00	117	
2	25	est.	117	
			234	4.9
Powell River				
1	32	1.00	91	
2	26	1.00	80	
			171	3.6
TOTAL			4744	100.0

Table 3. Distribution of questionnaire responses and airfills by sample location.

Location	Responses		Airfills	
	Number	Percent	Number	Percent
Vancouver				
1	26		126	
2	13		112	
3	13		814	
4	21		106	
	73	47.1	2928	61.7
Victoria				
1	21		146	
2	15		223	
	36	23.2	1059	22.3
Nanaimo				
1	6		18	
2	9[a]		334	
	15	9.7	352	7.4
Campbell River				
1	13		117	
2	1		117	
	14	9.0	234	4.9
Powell River				
1	17		73	
	17	11.0	171	3.6
TOTAL	155	100.0	4744	100.0

[a]Mid-December sample.

Table 4. Summary of resident and visitor responses from the sample locations.

Location	N	Resident	Visitor
Vancouver			
1	26	24	2
2	13	11	2
3	13	13	0
4	21	21	0
	73	69	4
Victoria			
1	21	20	1
2	15	15	0
	36	35	1
Nanaimo			
1	6	4	2
2	9	9	0
	15	13	2
Campbell River			
1	13	10	3
2	1	1	0
	14	11	3
Powell River			
1	17	11	6
TOTAL	155	139	16

Table 5. Respondent experience levels by sample location.

Location	Beginner <50	Intermediate 50 to 100	Advanced 100 to 500	Expert >500	N
Vancouver					
1	4	6	14	2	26
2	5	4	3	1	13
3	2	2	5	4	13
4	10	2	9	0	21
	21	14	31	7	73
Victoria					
1	9	5	6	1	21
2	0	3	7	5	15
	9	8	13	6	36
Nanaimo					
1	3	1	1	1	6
2	3	1	4	1	9
	6	2	5	2	15
Campbell River					
1	4	4	2	3	13
2	0	1	0	0	1
	4	5	2	3	14
Powell River					
1	6	2	5	4	17
TOTALS	46	31	56	22	155
%	29.7	20.0	36.1	14.2	

Table 6. Distribution of dive descriptions and questionnaires by sample location.

Location	Number questionnaires	Number dives	Number dives/resp.	Percent questionnaires	Distribution dives
Vancouver					
1	26	92	3.54		
2	13	62	4.77		
3	13	60	4.62		
4	21	104	4.95		
	73	318	4.36	47.4	44.8
Victoria					
1	21	111	5.28		
2	15	71	4.73		
	36	182	5.06	23.4	25.7
Nanaimo					
1	6	18	3.00		
2	9	52	5.78		
	15	70	4.67	9.7	9.9
Campbell River					
1	1	6	6.00		
2	13	49	3.77		
	14	55	3.93	8.4	7.8
Powell River					
1	17	90	5.29	11.0	11.8
TOTALS	155	715	4.60	100	100

Table 7. Estimated questionnaire sampling rates based on the numbers of airfills and dive descriptions.

Location	Number of airfills	Number of dive descriptions	Percent sampled	Sample range	
				Min.[a]	Max.[b]
Vancouver	2928	146	4.98	3.32	9.96
Victoria	1059	78	7.41	4.91	14.82
Nanaimo	352	30	8.52	5.68	17.04
Campbell River	234	30	12.93	8.54	29.97
Powell River	171	45	27.44	17.54	57.41

[a]Min = (Dives) (Airfill x 1.5)$^{-1}$

[b]Max = (2 x dives) (Airfill)$^{-1}$

Table 8. Area scaling factors calculated using the numbers of airfills and dive descriptions.

Location	Number of dive descriptions	Number of airfills	Scaling factor
Vancouver	210	2928	13.94
Victoria	127	1059	8.34
Nanaimo	40	352	8.80
Campbell River	47	117	2.49
Powell River	64	171	2.67
TOTAL	488	4627	

Table 9. Distribution of dive descriptions by activity type and respondent experience level.

Experience level	Sight-seeing	Photo-graphy	Spear-fishing	Collection		Number of dives
				edible	nonedible	
Beginner	80.9	0.4	0.6	7.5	3.3	178
Intermediate	80.6	2.4	10.5	4.0	2.4	124
Advanced	59.4	13.8	13.3	11.4	2.0	202
Expert	37.2	17.4	12.8	9.3	23.2	86

Table 10. Number of diver activities listed according to experience level (n = 118 respondents).

Experience level	No. activities listed	
	1	≥2
Beginner	29	14
Intermediate	19	10
Advanced	21	6
Expert	9	10

Table 11. Diver collection preferences for common marine animals.

Type of animal	Mean rank	Collection habits (%)			N
		Never	Upon occasion	When available	
		Fish			
Lingcod	2.13	40.0	33.3	26.7	150
Rockfish	2.54	64.9	24.5	10.6	151
Other fish	2.87	88.1	10.5	1.3	151
		Invertebrates			
Abalone	2.35	50.0	35.3	14.7	150
Dungeness crab	2.35	52.3	30.5	17.2	151
Rock scallop	2.35	52.3	30.5	17.2	151
Rock crab	2.60	69.1	22.1	8.8	149
Swimming scallop	2.71	78.1	14.6	7.3	151
Prawn	2.77	83.4	9.9	6.5	151
Sea cucumber	2.83	85.4	11.9	2.7	151
Sea urchin	2.92	92.7	7.3	0	151
Octopus	2.99	99.3	0.7	0	151

Table 12. Summary of diver collections of common marine animals.

Type of animal	Divers who collect (%) Overall	Last dive only	N
	Fish		
Lingcod	60	35	150
Rockfish	35	18	151
Other fish	12	3	151
	Invertebrates		
Abalone	50	22	150
Dungeness crab	48	17	151
Rock scallop	48	19	151
Rock crab	31	12	149
Swimming scallop	22	8	151
Prawn	17	5	151
Sea cucumber	15	4	151
Sea urchin	7.3	2.8	151
Octopus	0.6	0.6	151
	Summary		
Any fish	61	40	
Any invertebrate	74	44	
Anything	78	53	

Table 13. Collection rates and the estimated total catch for common marine animals.

Type of animal	Collection rate			Number of collecting dives	Estimated catch	
	Mean	SE	N		Survey period	Per 1000 sport dives
			Fish			
Lingcod	1.90	0.14	51	1490	2830	693
Rockfish	2.77	0.36	26	710	1965	487
Other fish	1.60	0.40	5	114	183	45
			Invertebrates			
Abalone	6.19	0.84	32	773	4786	1172
Dungeness crab	3.36	0.36	25	715	2401	588
Rock scallop	4.89	0.96	28	749	3663	903
Rock crab	2.94	0.30	17	439	1292	316
Swimming scallop	15.54	4.12	11	320	4972	1281
Prawn	15.86	6.36	7	215	3409	835
Sea cucumber	4.67	1.63	6	102	474	116
Sea urchin	7.50	5.54	4	117	877	215
Octopus	1.00	-	1	9	9	2.1

DIVER SURVEY QUESTIONNAIRE DATE _____

1/ What is your city or town of residence? _____

2/ Check the appropriate space to indicate the total number of recreational dives you have made in your diving career.

Less than 50 _____ 100 - 500 _____

50 - 99 _____ greater than 500 _____

3/ Please indicate the approximate number of recreational dives you have made in B.C. this year.

Jan. - Mar. _____ Jul. - Sept. _____

Apr. - Jun. _____ Oct. - Dec. _____ (estimated)

4/ In the table below describe your most recent recreational dives this year and your next dive if one is planned.

DIVE	DATE (Month)	LOCATION NUMBER (See display map)	PRINCIPLE UNDERWATER ACTIVITY (check one for each dive)				
			SIGHTSEEING	PHOTOGRAPHY	SPEARFISHING	COLLECTION (edible)	COLLECTION (non-edible)
1							
2							
3							
4							
5							
Next Dive							

5/ In the table below please estimate the percentage of dives associated with each activity for all dives you made in B. C. this year.

ACTIVITY	PERCENTAGE OF TOTAL DIVES THIS YEAR (check one for each activity)					
	0	1 - 20	21 - 40	41 - 60	61 - 80	81 - 100
Sightseeing						
Photography						
Spearfishing						
Collection (edible)						
Collection (nonedible)						

(continued on reverse)

6/ Below is a list of marine animals commonly taken while diving. Please check your collection habits as a diver for each item in Column I and indicate the number taken on your last dive in Column II.

ANIMAL	I YOUR COLLECTION HABITS (check one for each animal)			II NUMBER TAKEN ON LAST DIVE
	When Available	Upon Occasion	Not Taken	
Lingcod				
Rockfish (Red Snapper, Rockcod, Sea Bass)				
Other fish				
Dungeness crab				
Rock crab				
Abalone				
Rock scallop				
Swimming scallop				
Octopus				
Prawns				
Sea Urchin				
Sea Cucumber				
Other (specify)				

Thank you for your time and efforts in completing this questionnaire. Using the space below, please feel free to comment about any issue that concerns you.. For example, this study, fisheries regulations which apply to divers, or favorite diving areas.

Fig. 1. Questionnaire used in recreational diver survey.

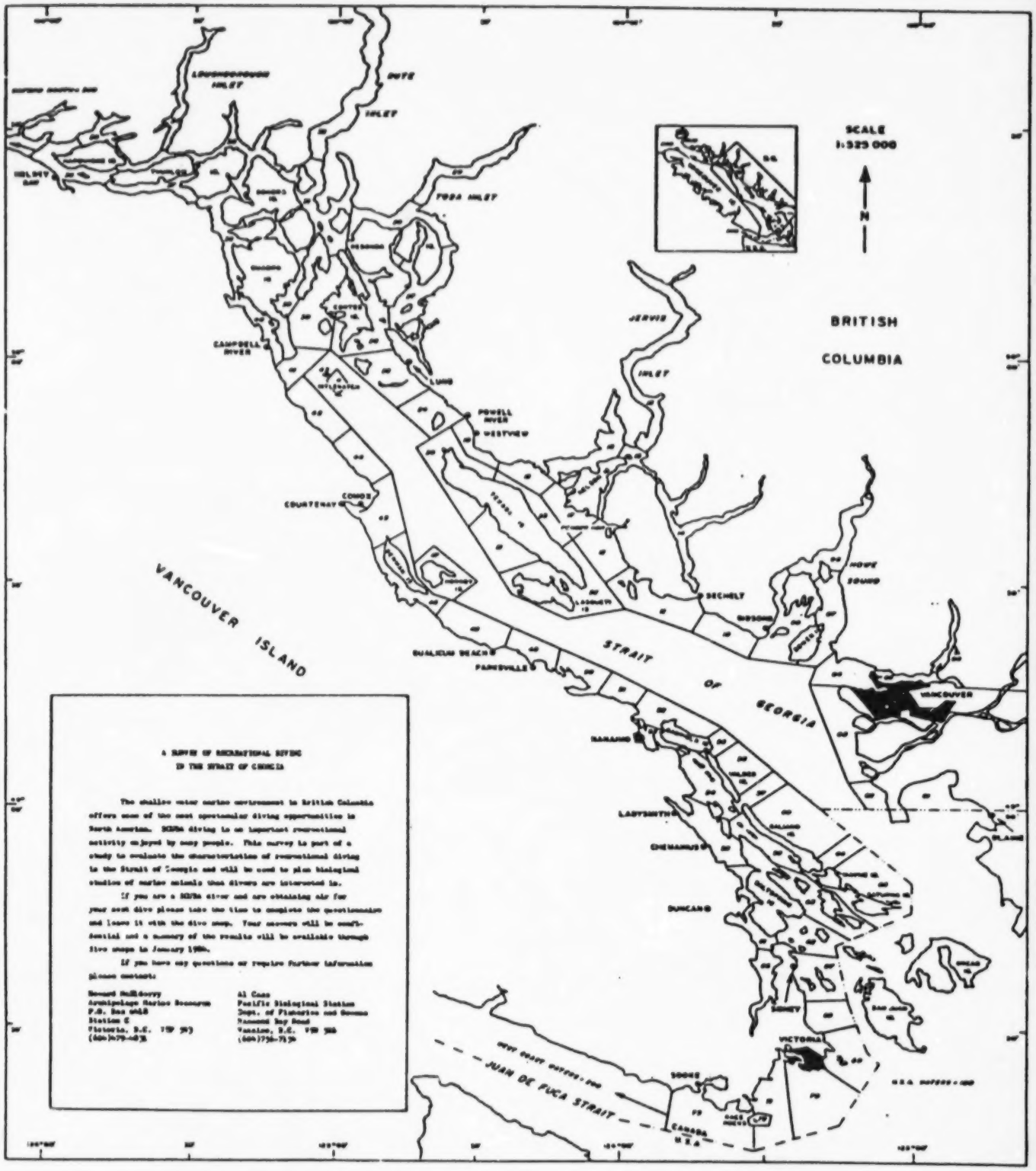

Fig. 2. Strait of Georgia display map posted at sample locations.

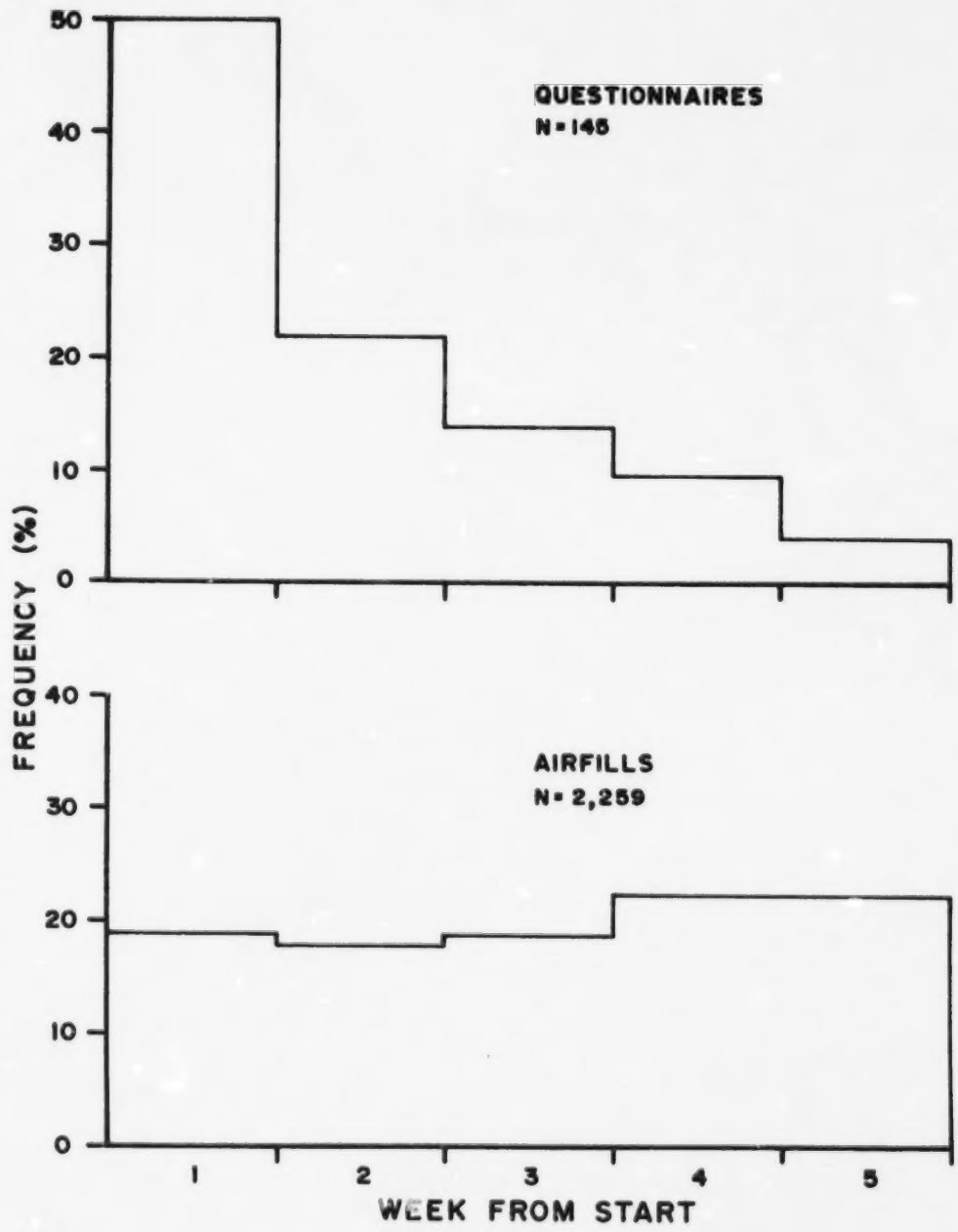

Fig. 3. The frequency distribution of questionnaire responses and airfills over the survey period.

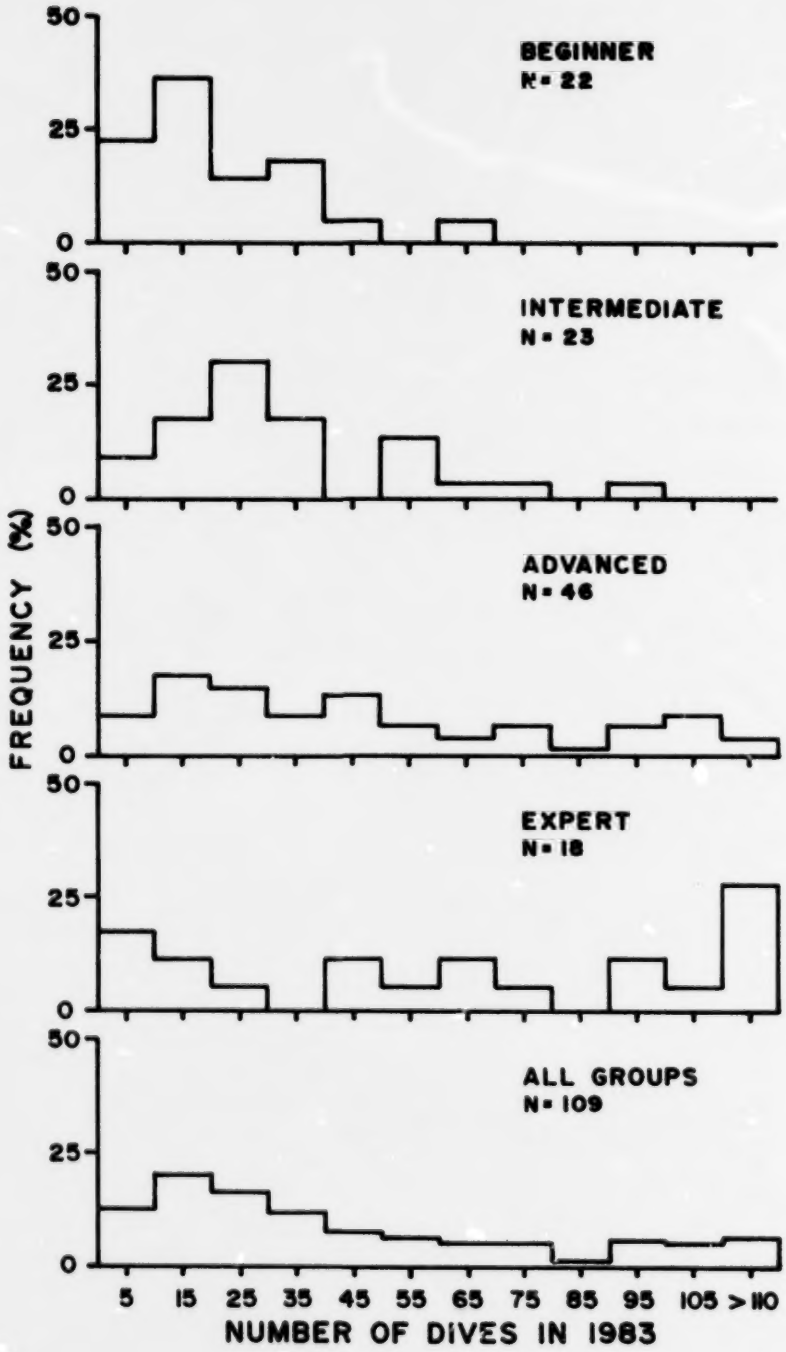

Fig. 4. The frequency distribution of the number of recreational dives in 1983 according to experience level for all sample groups combined.

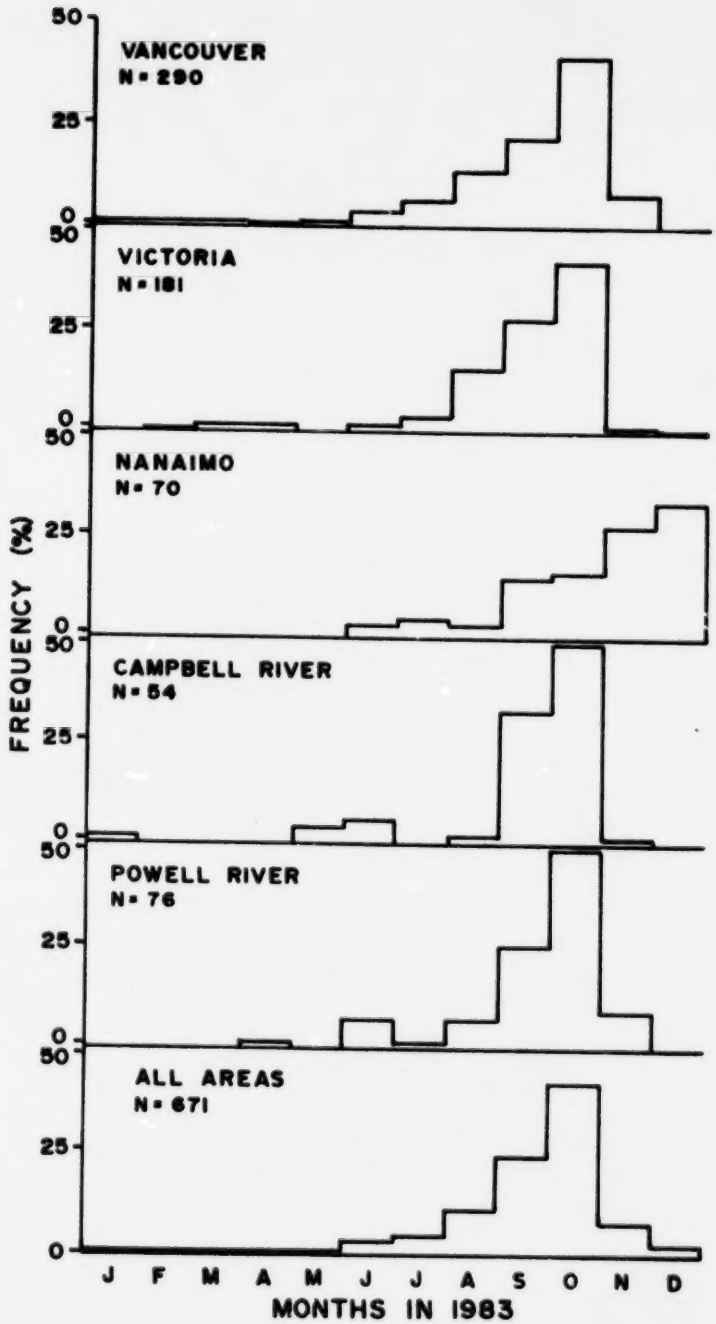

Fig. 5. The frequency distribution of dive descriptions by month and sample location.

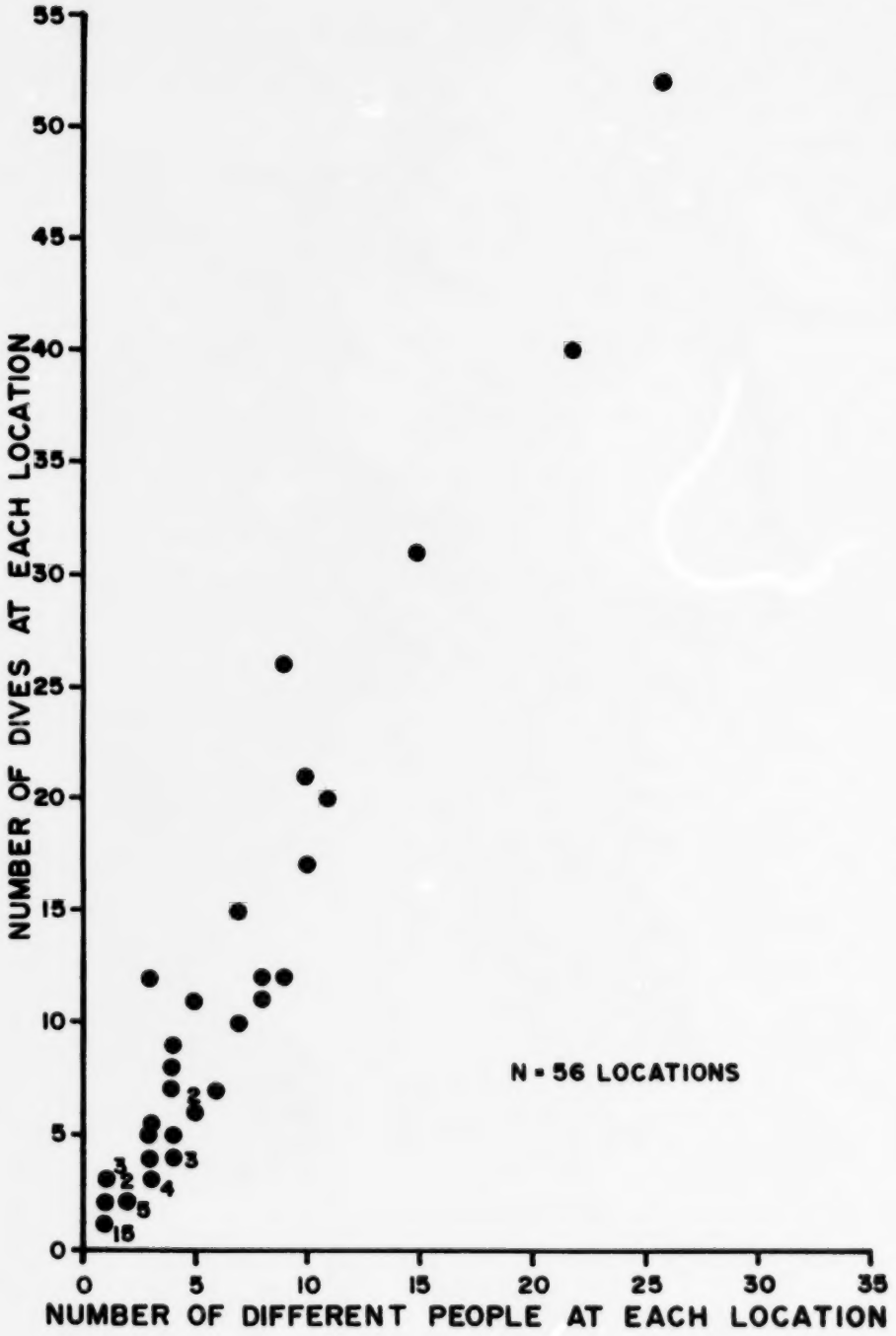

Fig. 6. The relationship between dives and divers in describing locations.

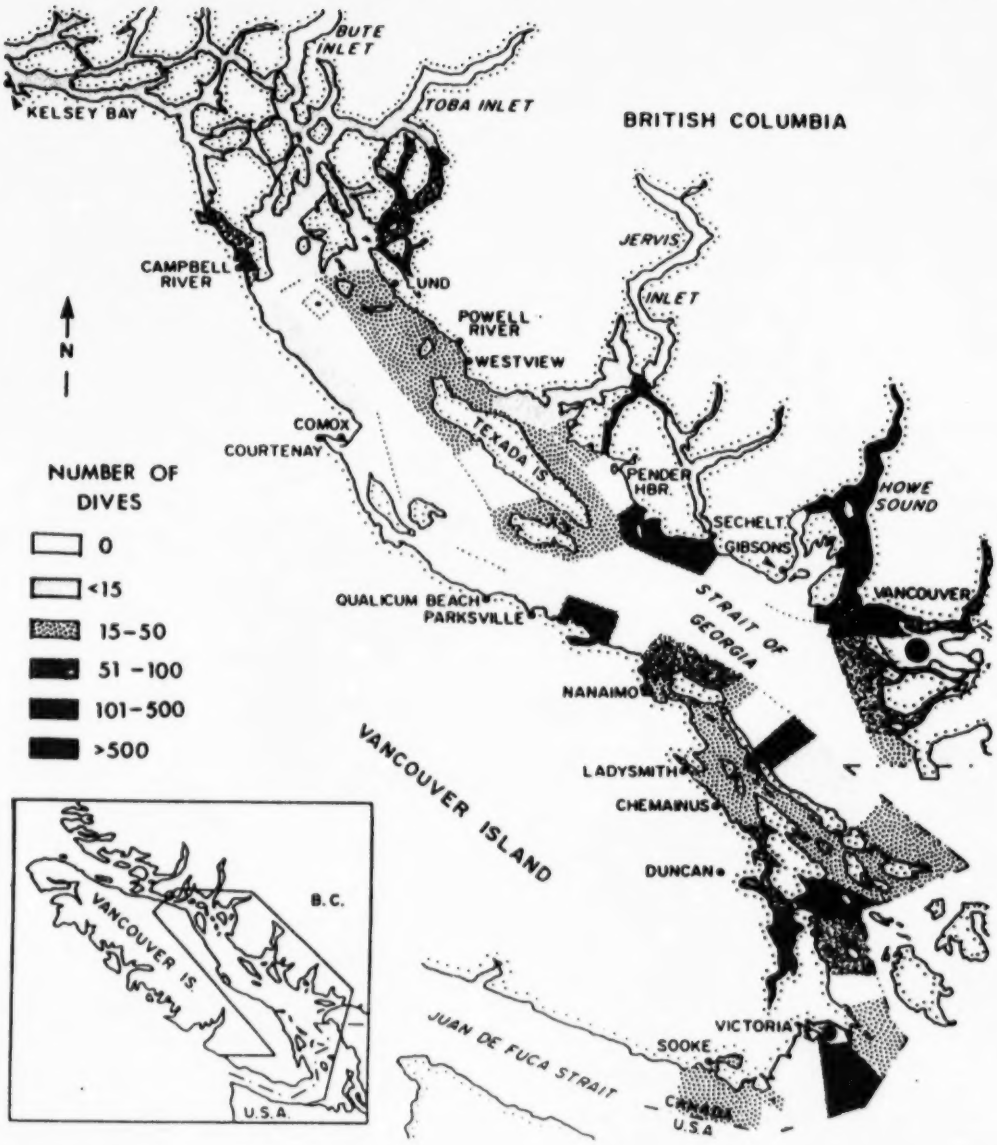

Fig. 7. The overall distribution of diving effort in the Strait of Georgia.

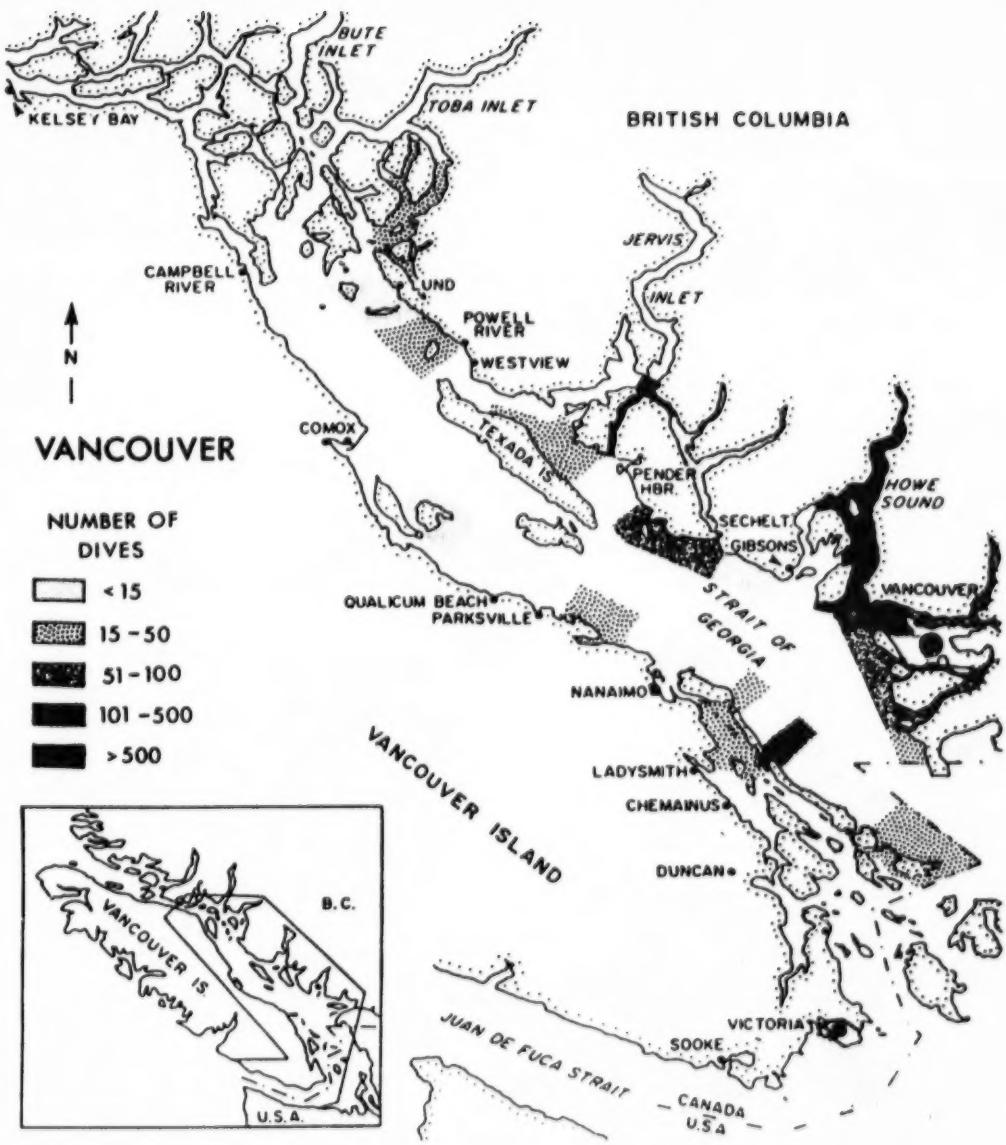

Fig. 8. The distribution of diving effort in the Strait of Georgia for Vancouver sample locations.

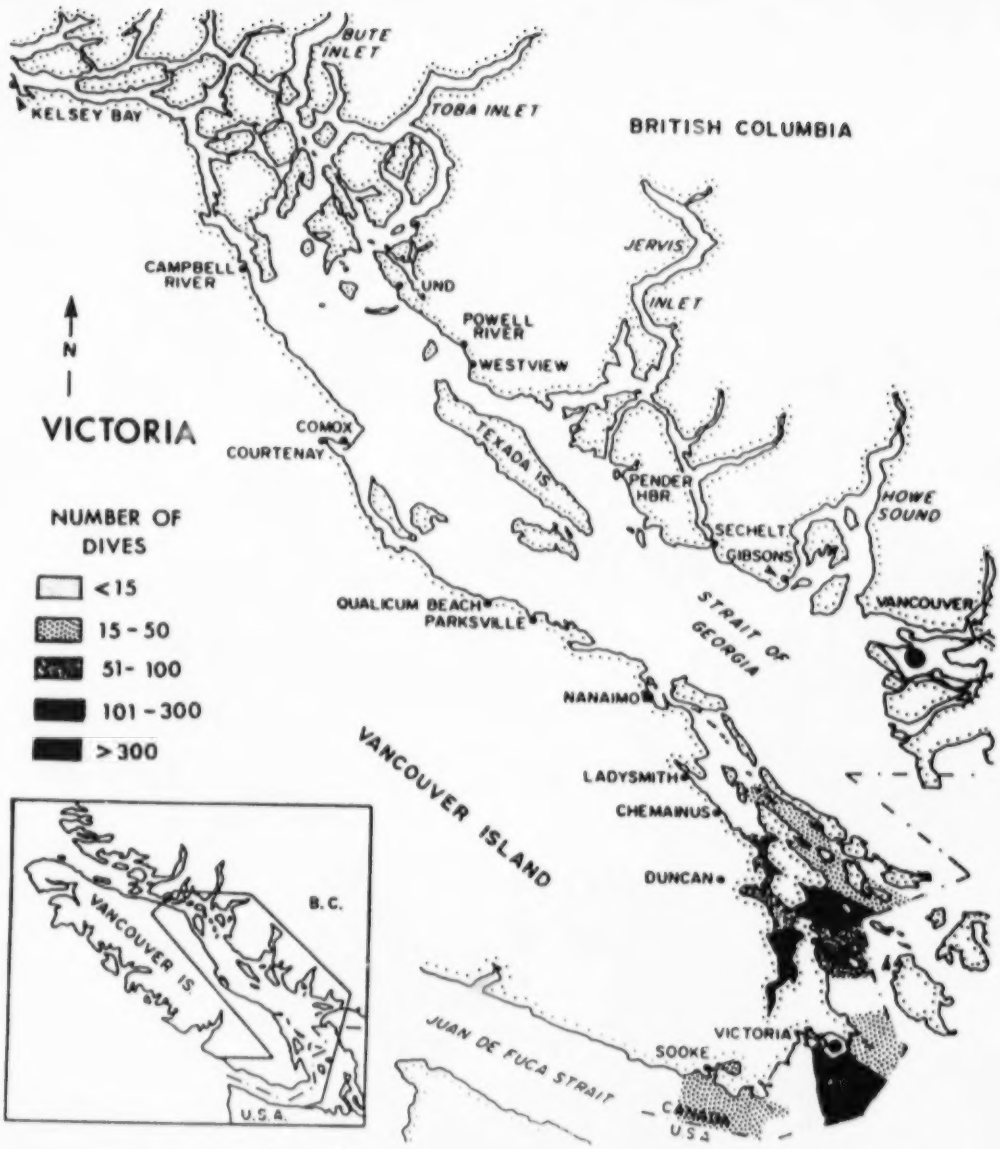

Fig. 9. The distribution of diving effort in the Strait of Georgia for Victoria sample locations.

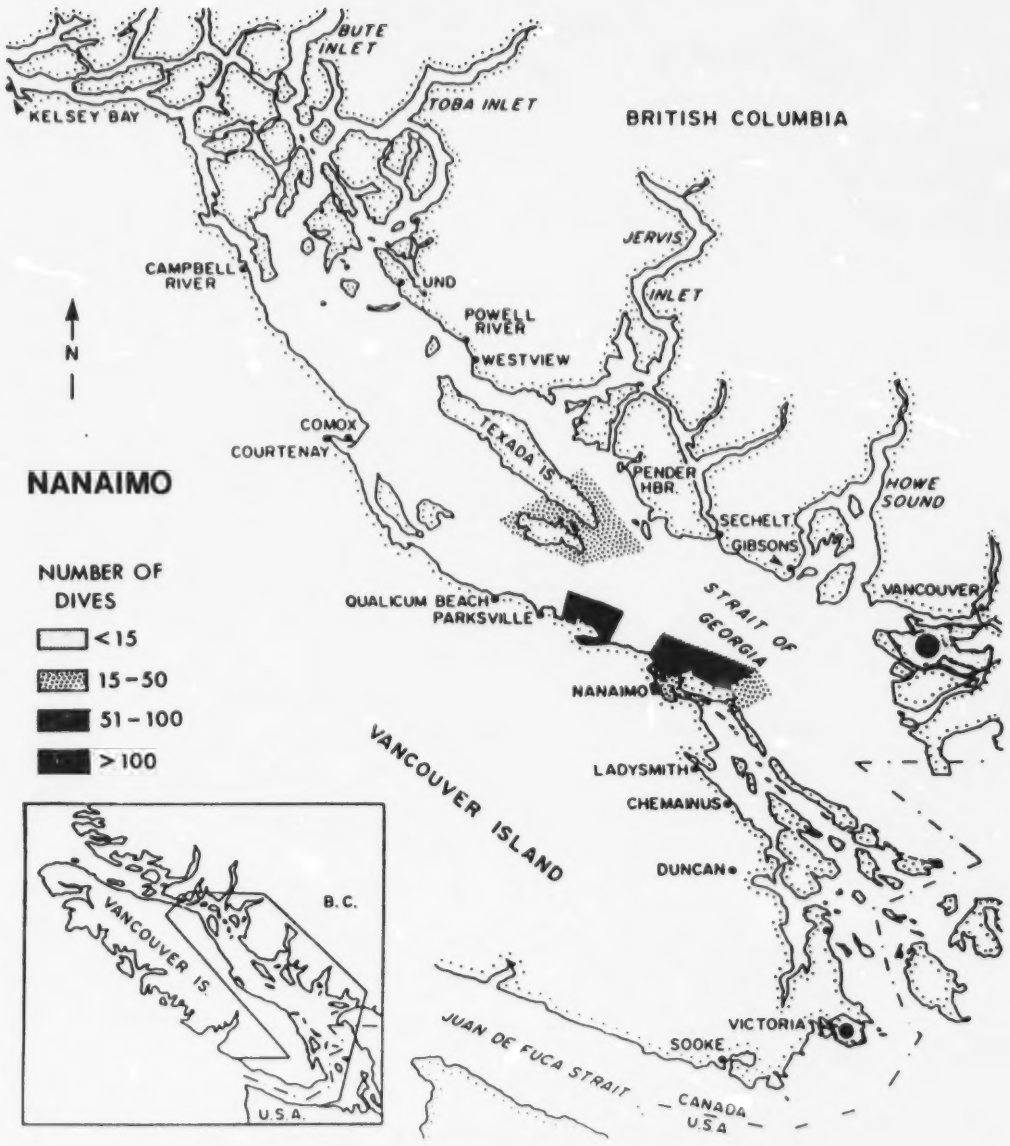

Fig. 10. The distribution of diving effort in the Strait of Georgia for Nanaimo sample locations.

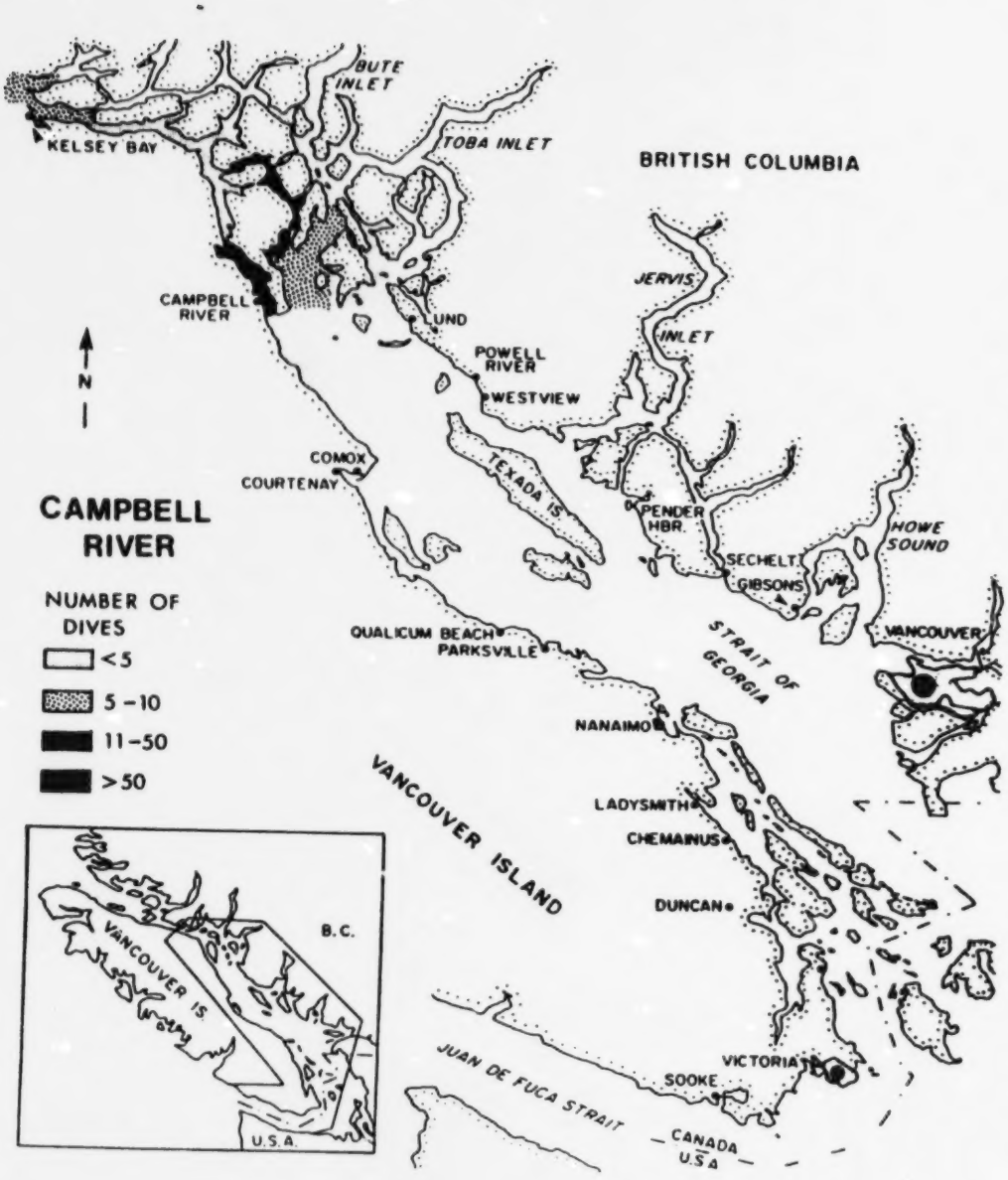

Fig. 11. The distribution of diving effort in the Strait of Georgia for Campbell River sample location.

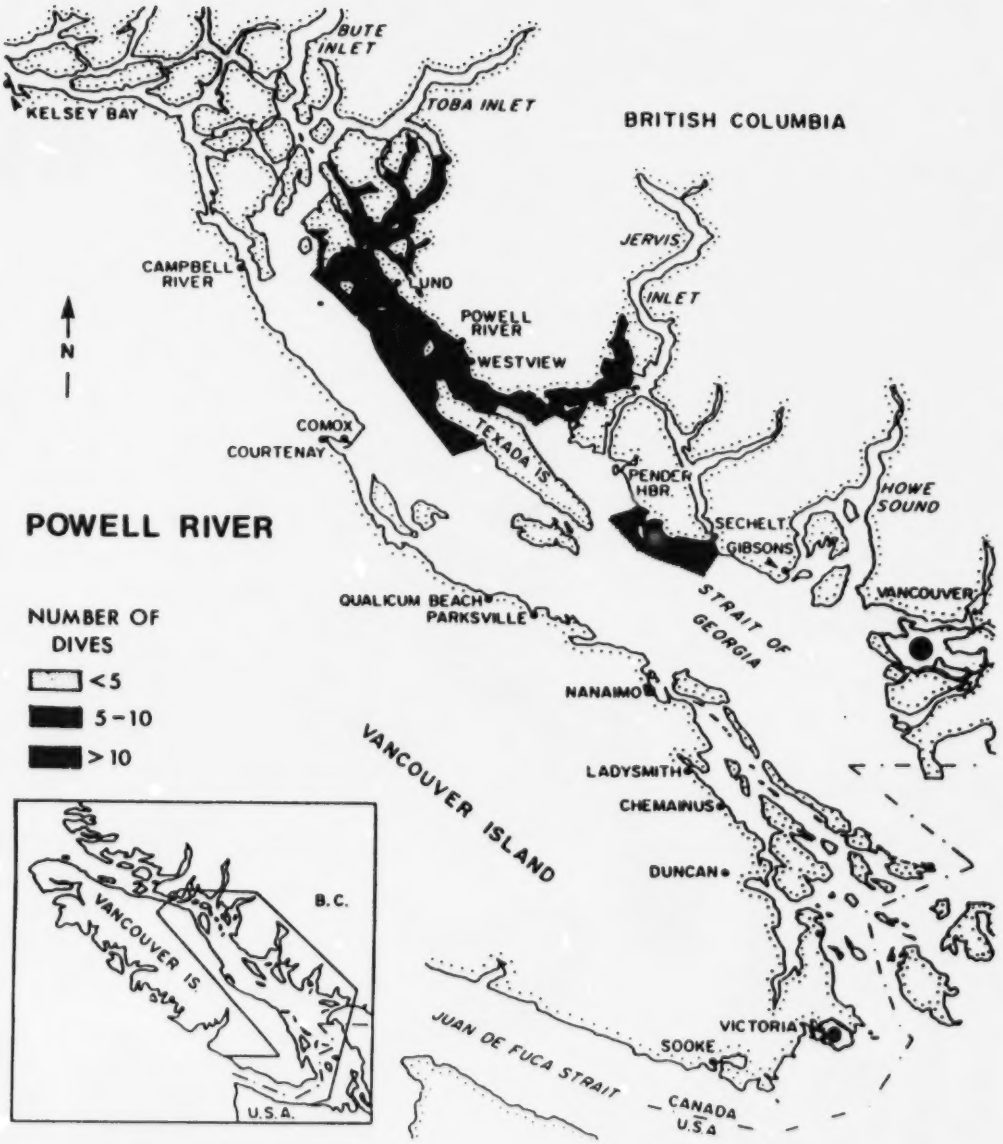

Fig. 12. The distribution of diving effort in the Strait of Georgia for Powell River sample location.

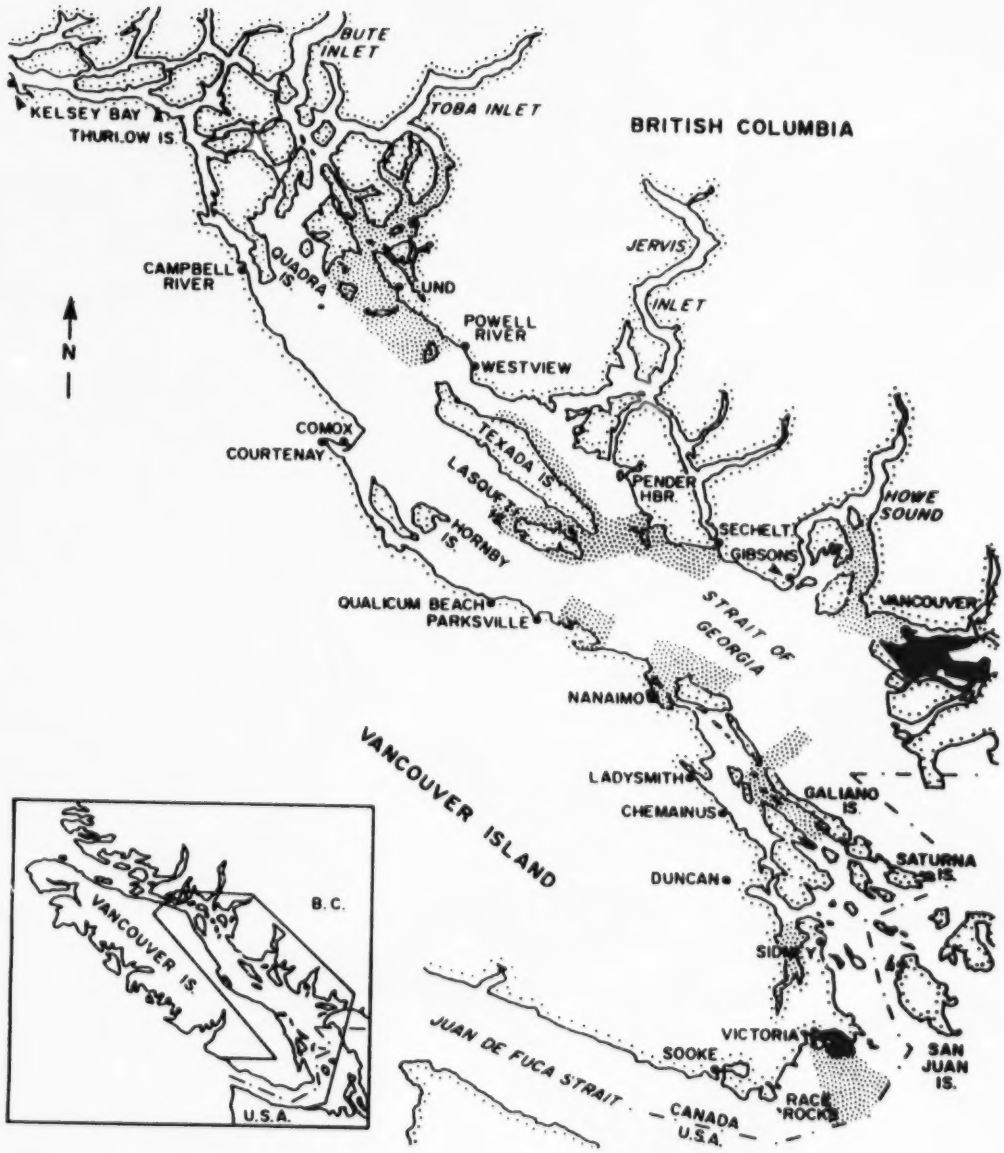

Fig. 13. Dive areas in the Strait of Georgia reported from two or more sample locations.

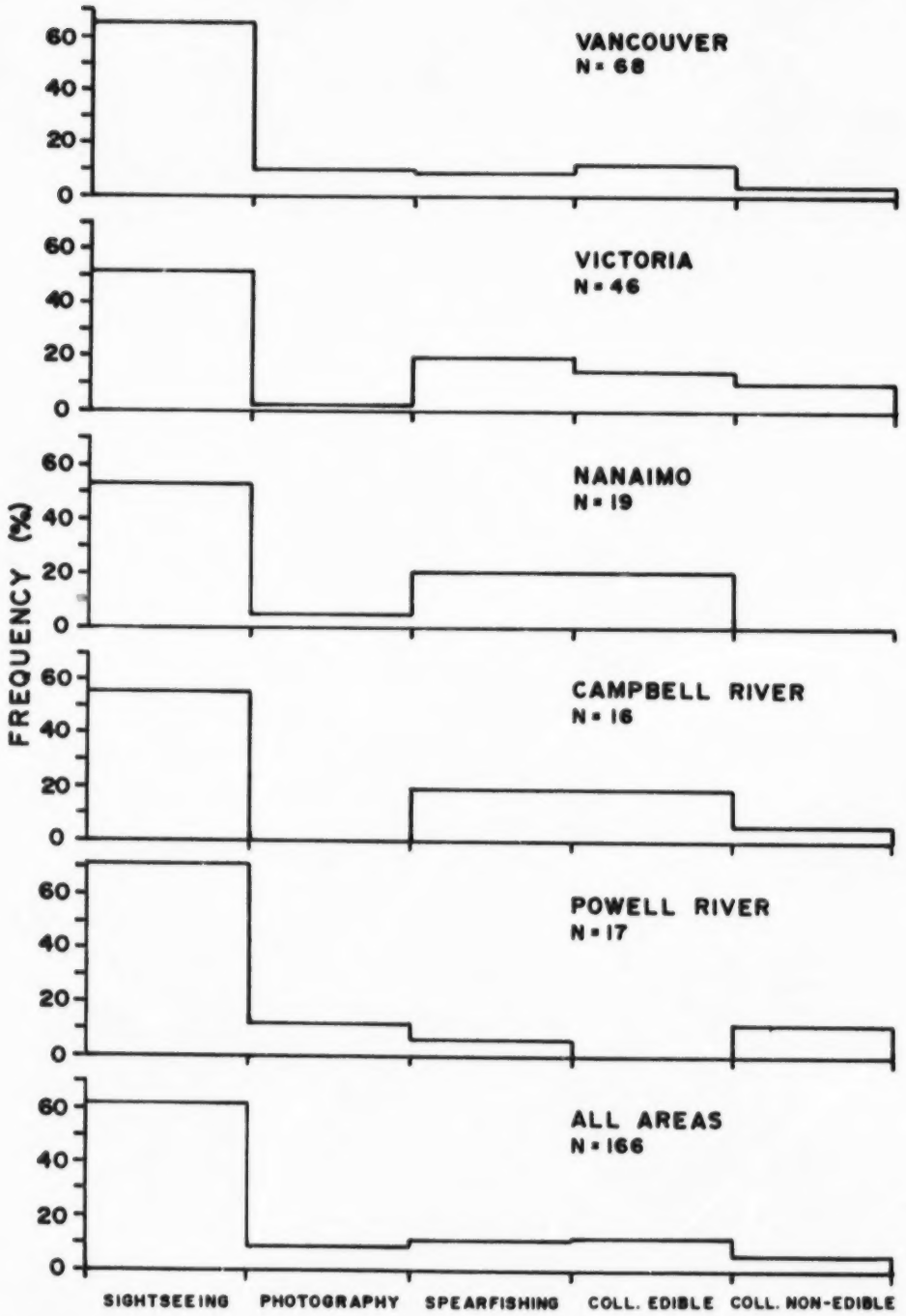

Fig. 14. The frequency distribution of principal dive activities for each sample region, based on the number of participants in each activity.

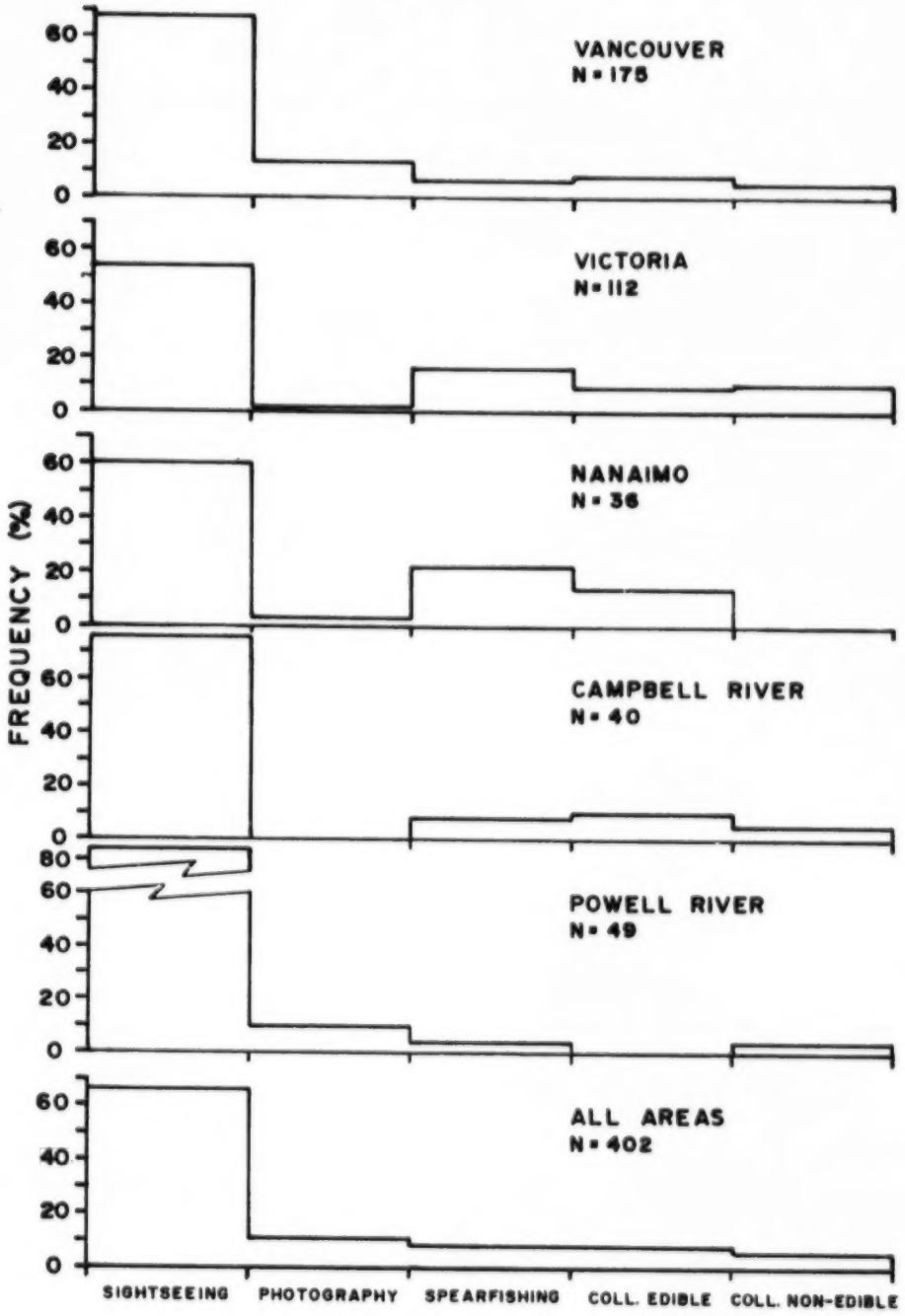

Fig. 15. The frequency distribution of principal dive activities for each sample region, based on the number of dives spent at each activity.

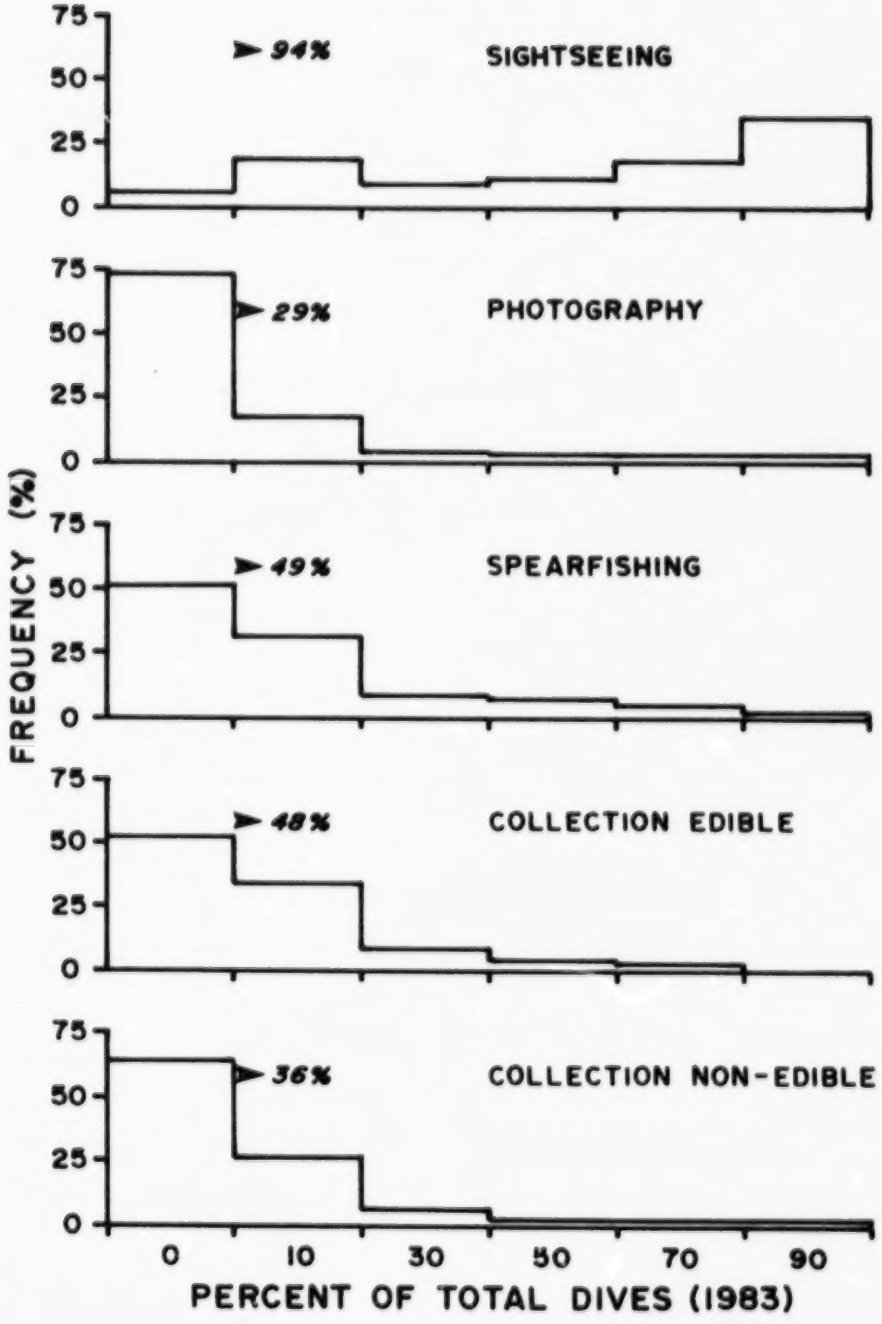

Fig. 16. The frequency distribution of dive descriptions for each principal dive activity. Values indicate the percentage of non-zero responses.

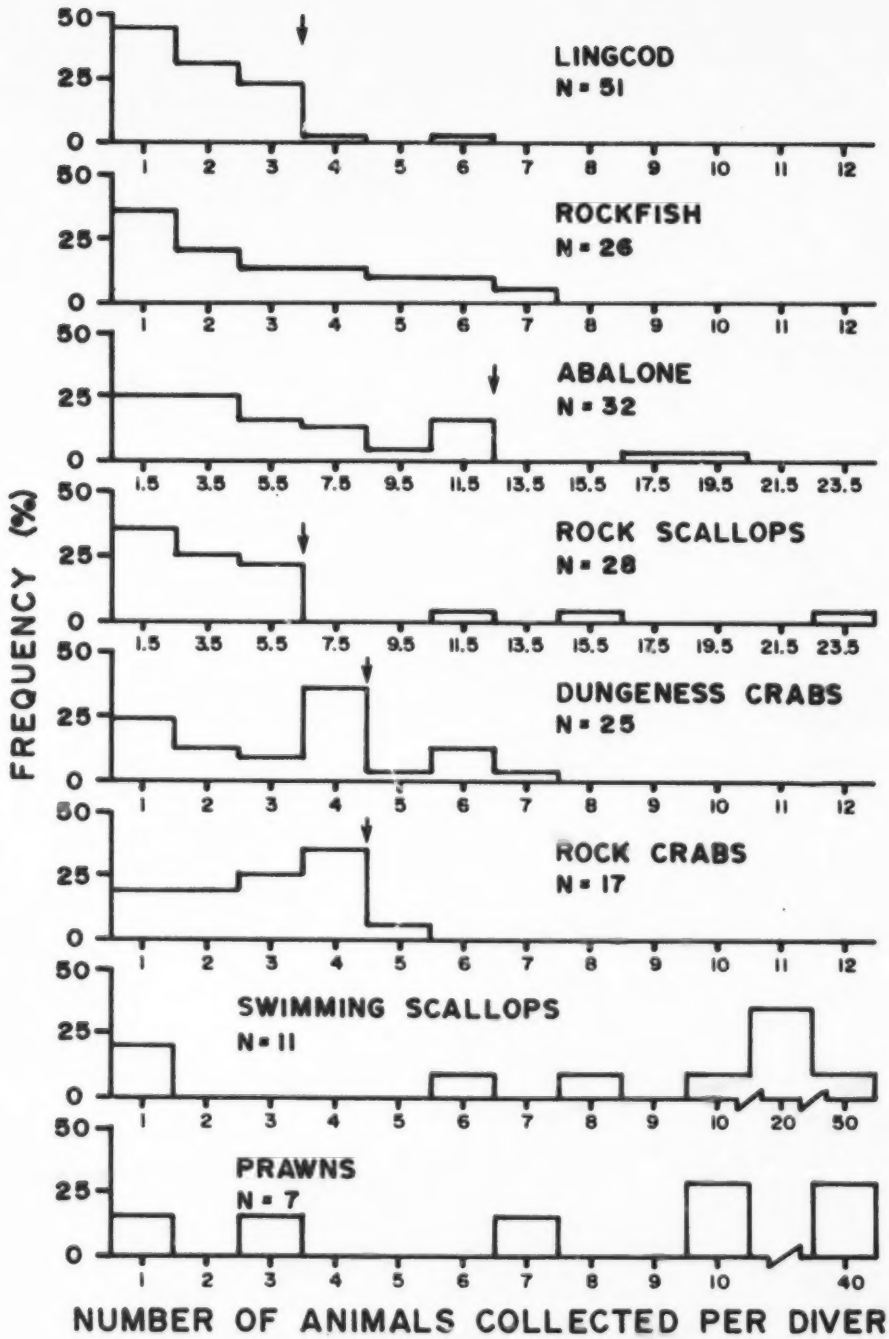

Fig. 17. Collection frequencies for common marine animals taken on the last dive.